inter·noise 83

AIRBORNE AND STRUCTURE BORNE SOUND ON OFFSHORE PRODUCTION PLATFORMS

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INTRODUCTION

Offshore production platforms, used for the production of oil and gas in the North Sea area, are very complex with regard to design and construction. Most platforms are modular in design. This means the jacket legs are put into position first and then the topsides are built up from prefabricated steel units and connected together (fig. 1). Besides the accommodation module, there are amongst others: production modules, generator modules, pump modules with a great complexity of machinery as controle valves, pipe-work, vessels and others. Most of the equipment produces or transmits airborne and structure borne sound.
The most important reasons to control the noise levels on offshore platforms are:
- to ensure sufficient low noise levels in recreation and sleeping areas
- to reduce the risk of hearing damage
- to allow communication systems to be intelligible
- to ensure voice to voice communication where required

NOISE REGULATIONS

Besides the internal regulations of the owners of platforms, the different governments have made noise regulations. Some noise limits are given in Table I.
It will be clear that most problems arise in practice to meet the noise limits in the sleeping areas, especially on installations where the accommodation areas are mounted on the production platforms itself. This kind of platforms is often used for the smaller oil- and gas fields in the North Sea.

Table I Noise limits

Lokation	Requirements dB(A) acc:	
	1	2
sleeping area	45	45
hospital	45	45
mess rooms	55	55
recreation areas	55	50
radio and telecomm.rooms	55	45
control room	55	55
kitchen, washrooms	-	60
workshops, stores	-	70
general working areas > 80 dB(A)	hearing conservation aids	88

1) Dutch: Staatstoezicht op de mijnen; Guidelines for the accomodation on mining installations 27-10-'82

2) British: Department of Energy: Offshore installations: "Guidance on design and construction" July 1977.

ACOUSTIC SURVEY

It is always necessary that the study of noise and vibration should be an integral part of the platform design. Changing a construction afterwards is in most cases impossible and always expensive. The study should begin with a preliminary study containing globally the starting points (noise- and vibration sources), the calculations of the airborne and structure borne sound transmission through the platform constructions and the resulting soundlevels in the different areas. The calculations are in practice often based on the results of measurements executed on existing platforms.
Table II gives some typical measured sound levels in dB(A) measured on different platforms in the North Sea and all over the world.

Table II Typical sound levels in dB(A)

Area	Noise levels dB(A)	Remarks
Power generation		
- gasengine	95 - 105	2 m distance
- air intake duct	90 - 95	1 m distance without silencer
- air outlet duct	95 - 100	1 m distance without silencer
- exhaust gasengine	95 - 100	2 m distance standard silencer
Production module	85 - 90	reverberant level
Well area	75 - 100	depending on setting valves
Seperator	70 - 75	1 m distance
Air compressor	80 - 90	1 m distance
After cooler	85 - 95	1 m distance

Especially for the smaller platforms without a separate accomodation area, the structure borne sound levels can have an important contribution to the sound levels inside the living quarters. Table III gives some measured vibration levels of equipment installed on platforms In practice depending on the impedancy large differences may occure.

Table III Typical acceleration levels dB (ref. $10^{-6}m/s^2$)

Measuring point	acceleration level dB (ref. $10^{-6}m/s^2$)						
	63	125	250	500	1000	2000	4000
gasengine (below mounting)	110	105	115	110	110	115	95
watermaker frame (vapour type)	105	115	120	115	130	135	130
diesel crane casing	80	90	110	110	110	115	105
glycol pump frame	95	100	105	120	135	130	120
pile production area	75	85	95	90	100	105	90
air compressor skid	105	105	115	125	120	125	110
structure living-quarter without additional damping	90	90	85	90	85	70	65

Soundlevels were measured between 45 and 60 dB(A) in the living quarters (bedrooms) of platforms without special sound and vibration provisions.
The calculated contribution of structureborne noise to these total soundlevels was 45 to 55 dB(A).
Especially to meet the requirements for bedrooms additional provisions are necessary in most cases.
For living quarters it is necessary to make a ratio between the contributions of external air-borne soundintrusion, structure borne sound caused by vibration in the structure of the platform and airconditioning and other technical installations within the living quarter.

It is important that already in the design phase all the noisy equipment should be located away from the accomodation, offices and other quiet areas. Buffer zones of more quiet machinery such as tankage areas, lay down areas,transformers and swithgear areas, should be provided between the noisy machinery areas and the accomodation.
As a result of a preliminary study the noise and vibration limits for individual items of machinery should be included as part of the general equipment specification issued to vendors These limits are based on the experience with similar equipment as well as on the desired levels based on the requirements.
The individual limits should be set,taking into account the location of all equipment in a particular area and its acoustical environment, in a way that total relevant area noise criteria will be achieved.
Calculations can be made of the airborne and structure borne soundlevels on the relevant places on a platform based on the limits as mentioned above. Table IV gives an example of a computer output for the outside noise levels of a living quarter. Also for the different decks equi-dB(A) contour maps can be made to indicate the areas where acoustical problems can be expected.

Table IV LIVING QUARTERS OUTSIDE NOISELEVELS
CALCULATION BASED ON REQUIREMENTS

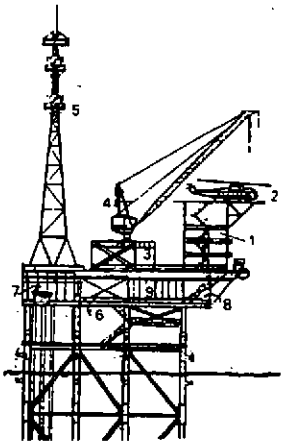
BOUNDARY	DESCRIPTION	DB(A)	63	125	250	500	1K	2K	4K
NORTH	CELLAR + A	76	89	81	76	72	69	68	68
	CELLAR + A + CRANE	82	94	92	83	74	70	69	68
	CELLAR + A + B	86	99	91	86	82	79	78	78
	CELLAR + A + B +CRANE	87	100	95	88	82	79	78	78

Based on the results of the calculations, detailed acoustical provisions can be indicated in the project study. In general the following provisions may be necessary:

- vibration isolated mounting of engines and gas-turbines
- silencers for air intake and outlet of generator buildings
- additional sound absorption material in generator rooms
- vibration isolated mounting living quarters
- additional soundinsulation of walls, floor, glass etc. of the living quarters, offices etc.
- additional soundinsulation between different rooms for good privacy
- acoustic ceiling in the living quarters
- A.C. installation: silencers, low noise fans, special ceiling grilles, special return air openings, flexibly connected ductwork

VIBRATION INSULATION OF LIVING QUARTERS

To meet the requirements for living quarters, in most cases a vibration isolating construction has to be used if a separate construction of the living quarters is not applicable. For the calculation of the additional damping it is necessary to predict the normal damping between the piles and the supporting structure of the living quarters. Based on calculations and measurements in particular cases this damping can be 10-20dB for frequencies between 250 and 4000 Hz.



The additional elastic mountings will have in practice a stiffness, that gives vertical natural frequencies (vertical) of around 5-12 Hz, depending on the needed damping and the exitated frequencies in the structure. Besides the calculation of the vertical natural frequencies of other vibration modes (rotational and coupled modes) and the effect of static and dynamic side loads (wind).

1. living quarter
2. helideck
3. production modul
4. crane
5. commun.tower
6. generator building
7. welldeck
8. pumparea
9. tankage area

Figure 1 Production platform